A Simple Method for Computing Global Solar Radiation

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Abstract - *In this paper a simple correlation is developed to predict monthly average daily global solar radiation on horizontal surfaces for different Algerian locations. The suggested model expresses global radiation in terms of the per cent possible sunshine and the noon height of the sun on the 15th of the month. The agreement between the measured and the computed values is remarkable and the model is recommended for use in any location in Algeria.*

Keywords: Global radiation - Horizontal surface - Sunshine duration.

1. INTRODUCTION

Solar energy occupies one of the most important places among the various possible alternative energy sources. An accurate knowledge of solar radiation distribution at a particular geographical location is of vital importance for the development of many solar energy devices and for estimates of their performances. Unfortunately, for many developing countries solar radiation measurements are not easily available for not being able to afford the measurement equipment and techniques involved. Therefore, it is rather important to elaborate methods to estimate the solar radiation on the basis of more readily meteorological data.

Over the years, many models have been proposed to predict the amount of solar radiation using various parameters [1-12]. Some works used the sunshine duration [1-8], others used mean daytime cloud cover or relative humidity and maximum and minimum temperature [9-11], while others used the number of rainy days, sunshine hours and a factor that depends on latitude and altitude [12].

Algeria is a high insolation country. The number of sunshine hours amounts almost 3300 h./year. The climate is most favourable for solar energy utilisation, but the distribution of the solar radiation is not well known. The importance of this work lies on the fundamental need of knowledge of the global solar radiation data in the country.

In this paper, a simple model has been tested for different algerian locations. It only requires the duration of sunshine and the noon height of the sun on the 15th of the month.

2. CALCULATION PROCEDURE

In the present work, data of monthly mean of daily global solar radiation and sunshine duration from four Algerian meteorological stations (Algiers, Oran, Bechar and Tamanrasset) are used [4]. The geographical location of stations are presented in table 1. The duration of records of sunshine duration is 25 years and of global solar radiation is approximately 10 years. Measurements of global solar radiation were performed with Robitzsh and Kip-Zonen pyranometers. For the recording of sunshine duration, Campbell-Stockes heliographs are used.

Table 1: Geographical location of stations

Station	Latitude (deg.) (N)	Altitude (m)	Longitude (degree)
Algiers	36.43	25	3.15 E
Oran	35.38	99	0.37 W
Bechar	31.63	806	2.40 W
Tamanrasset	22.47	1378	5.31 E

From the analyses of the data of the four stations the following relationship is obtained:

$$G / G_0 = K(S/S_0)^{0.63} \sin h^{-0.19} \quad (1)$$

Where G is the monthly average daily global radiation on a horizontal surface ($MJ.m^{-2}day^{-1}$), G_0 is the monthly average daily extraterrestrial radiation on a horizontal surface ($MJ.m^{-2}d^{-1}$), S is the monthly average daily number of hours of bright sunshine, S_0 is the monthly average daily maximum number of hours of possible sunshine and h is the noon solar altitude on the 15^{th} of the month (degrees). K is a zone parameter that depends on the climate.

G_0 and S_0 can be obtained from

$$G_0 = (24 I_0 / \pi)(1 + 0.033 \cos(360 N / 365)) \,.\, Z$$

$$Z = (\cos\lambda \cos\delta \sin\omega + 2\pi\omega \sin\lambda \sin\delta / 360) \quad (2)$$

$$S_0 = 2/15 \ \mathrm{ar}\cos(-\tan\delta \tan\lambda) \quad (3)$$

Where I_0 is the solar constant equal to 1367 Wm^{-2}, N is the day number starting from the 1st January, δ is the declination, λ is the latitude and ω is the hour angle. The coefficients a and b are determined by the method of least squares.

The four meteorological stations are divided into three zones according to the relative duration of sunshine.

- Mediterranean climate for Algiers and Oran.
- Sahara climate for Bechar.
- Tamanrasset which is influenced by the African tropical climate.

The relative percentage error is defined as follows :

$$e_i = (G_{i,m} - G_{i,c})(100 / G_{i,m}) \quad (4)$$

$G_{i,m}$ and $G_{i,c}$ are the i-th measured and computed values of global radiation.

3. RESULTS AND DISCUSSION

Using eq. (2), the monthly average daily global radiation values were calculated and appropriate zone parameters determined, K = 0.70 (Algiers and Oran), K = 0.73 (Bechar) and K = 0,77 (Tamanrasset). The best estimates of global radiation were obtained for Bechar and Tamanrasset. It is observed from the results that the maximum absolute percentage error between the measured and predicted values of global radiation are 7.13 per cent for Bechar, 8,48 per cent for Tamanrasset and less than 9.7 per cent for Algiers and Oran.

The variation of the daily global radiation measured and computed are represented in Figures (1-4). The peak solar insolation occurs in the cases of Algiers, Oran and Beni Abbes in June, July and for Tamanrasset in May-July, the solar radiation fluctuates from 22.21 $MJ.m^{-2}d^{-1}$ to 29.37 $MJ.m^{-2}d^{-1}$ for all the stations.

4. CONCLUSION

The monthly average daily global radiation incident on a horizontal surface has been estimated using the proposed model. The formula requires only the sunshine duration and the noon solar altitude of the sun. Appropriate zone parameters have been determined, K=0.7 for Algiers and Oran, K=0.73 for Bechar and K=0.77 for Tamanrasset. It is possible to determine other zone parameters by extending this model to other meteorological stations. The value of the constant K changes from place to place according to the climatic characteristics. The agreement between the measured and the estimated values is remarkable and it is recommended for use in any location in Algeria or stations with similar climate.

REFERENCES

[1] J. Canada, '*Global Solar Radiation in Pais Valenciano Using Sunshine Hours*', International Journal of Ambient Energy, 1988; 4: 197-201.

[2] J. Canada, '*Solar Radiation Prediction from Sunshine in Eastern Spain*', Renewable Energy, 1992; 3: 219-221.

[3] S.M.A. Ibrahim, '*Predicted and Measured Global Solar Radiation in Egypt*', Solar Energy, 1985; 35: 185-188.

[4] M. Capderou, '*Atlas Solaire de l'Algérie*', Office des Publications Universitaires, 'T'. 1-3, 1988.

[5] S. Barbaro, S. Copolino, C. Leone and E. Sinagra, '*Global Solar Radiation in Italy*', Solar Energy, 1978; 20: 431-435.

[6] K.J.A. Revfeim, '*On the Relationship Between radiation and mean daily sunshine Agricultural and Forest Meteorology*', 1997; 86:183-191.

[7] N. Halouani et al., '*Calculation of Monthly Average Global Solar Radiation on Horizontal Surfaces Using Daily Hours of Bright Sunshine*', Solar Energy, 1993; 50: 247-258.

[8] C. Gueymard, '*Analysis of Monthly Average Solar Radiation and Bright Sunshine for Different Thresholds at Cape Canaveral, Florida*', Solar Energy, 1993; 51: 139145.

[9] I. Supit and R.R. Van Kappel, '*A Simple Method to Estimate Global Radiation*', Solar Energy, 1998; 63:147-160.

[10] J.C Ododo, '*Prediction of Solar Radiation Using Only Maximum Temperature, and Relative Humidity*', Energy Conversion and Management, 1997; 38: 1807-14.

[11] J.C Ododo et al., '*The Importance of Maximum Air Temperature in the Parametrization of Solar radiation in Nigeria*', Renewable Energy, 1995; 6: 751-763.

[12] J. Canada, '*Global Solar Radiation in Valencia Using Sunshine Hours and Meteorological Data*', Solar & Wind Technology, 1988, 5: 597-599.

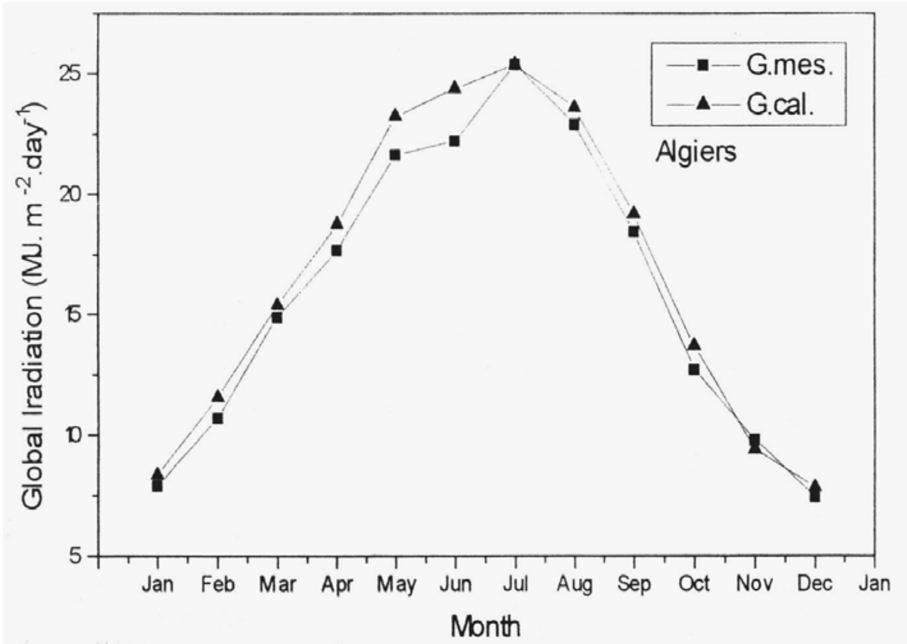

Fig. 1: The measured and calculated values of global solar radiation (Algiers)

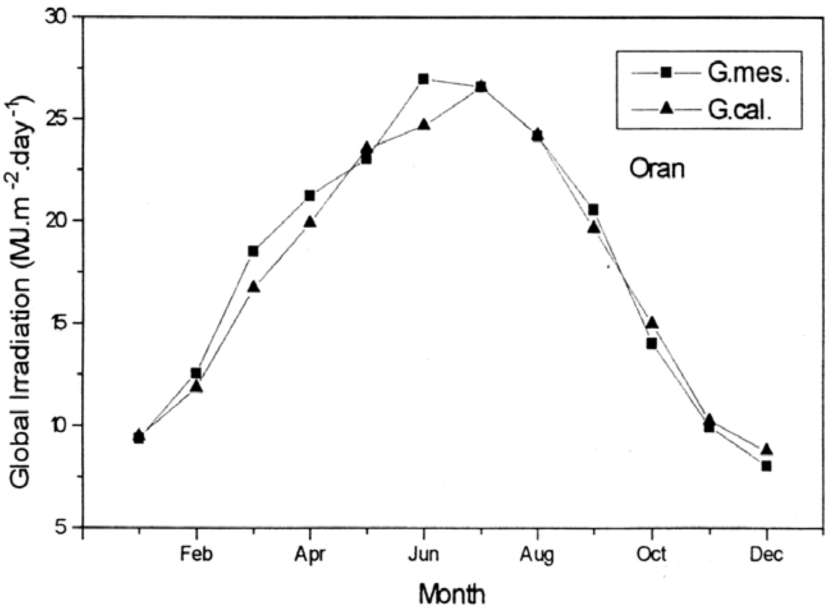

Fig. 2: The measured and calculated values of global solar radiation (Oran)

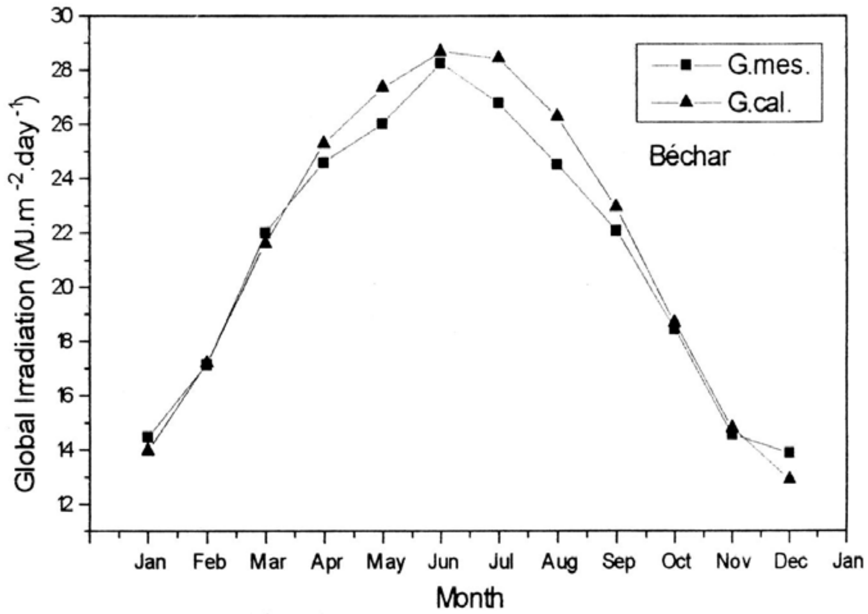

Fig. 3: The measured and calculated values of global solar radiation (Bechar)

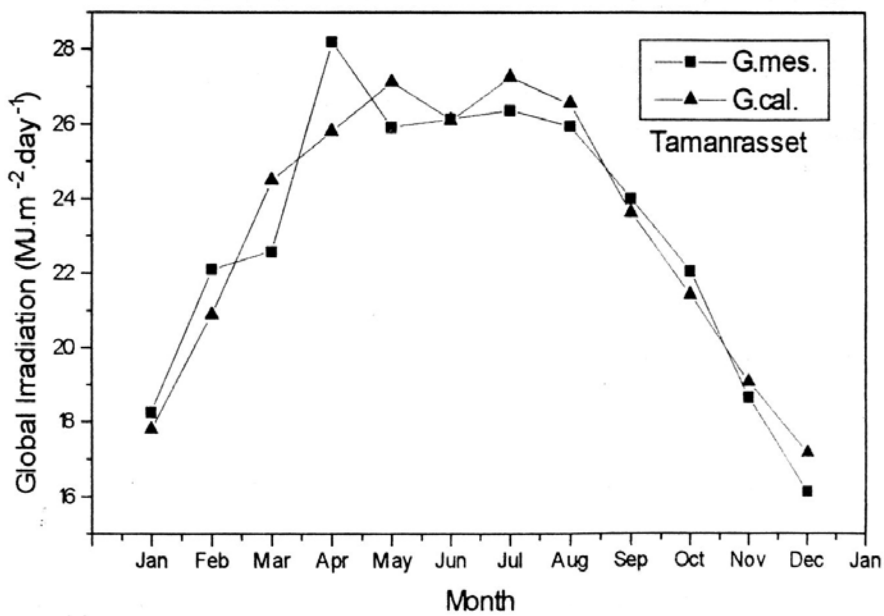

Fig. 4: The measured and calculated values of global solar radiation (Tamaanrasset)